FOSSIL MOLLUSKS AND DIATOMS FROM THE DISMAL SWAMP, VIRGINIA AND NORTH CAROLINA; INDICATION OF THE GEOLOGICAL AGE OF THE DEPOSIT.

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WITH NOTES ON THE DIATOMS.

BY CHARLES S. BOYER.

During the winter of 1897–98 the Dismal Swamp Canal was widened and deepened, and the level of the central portion lowered so as to dispense with the middle two of the four locks heretofore in use. The work was done by the McManus Construction Company of Philadelphia, steam rotary dredging machines being used in excavating. These dredges brought up from the bottom, at points both south and north of the Virginia-North Carolina boundary, large numbers of marine mollusks. Through the appreciative interest in scientific matters of M. Homer, Secretary and Treasurer of the Construction Company, we have been furnished on three occasions with specimens of these shells, which he specially and personally collected on his visits to the field of operations.

It is the purpose of this paper to put on record the species of these shells and also of the marine diatoms which were associated with them in the same matrix, and to indicate, though perhaps tentatively, from a study of both the macroscopic and microscopic fossils, the geological age of the bed from which they were obtained.

The Dismal Swamp Canal connects on the south at a point near South Mills, N. C., with the headwaters of the Pasquotank River, a tributary of Albemarle Sound, and on the north at a point near Deep Creek with the waters of the south branch of the Elizabeth River, a tributary of the James River and the Chesapeake Bay. The general direction of the canal between these two points is northward, with, however, a decidedly obtuse angled bend, or bow, to the westward, the angle being near Drummond Lake, from which a feeder canal brings the water from the lake into the main canal. This feeder was also deepened.

M. Homer states that the shells furnished by him were obtained from the following localities:—

1st.—A point on the main canal in North Carolina, two to three miles south of the Virginia boundary.

2d.—A point on the main canal in Virginia, about five miles north of the feeder, or four miles north of Wallaceton, a small Post Office and settlement on drained land near the centre of the swamp.

3d.—A point about midway of the feeder, say one and one-half miles west of its junction with the main canal.

A noticeable peculiarity, as stated by M. Homer, is that the collections from the main canal, from both the Virginia and North Carolina localities, contain great numbers of the large conch, *Fulgur carica*, while this shell is wanting in those thrown out from the feeder. Here, however, the oysters, *Ostrea virginica*, are exceedingly numerous, and many of them are of extra large size, one specimen in the possession of M. Homer measuring ten inches in length and four and one-half inches in width.

But few specimens, comprising only three species, were brought from the locality south of the Virginia-North Carolina line. M. Homer, however, states that the shells seemed as varied in form and as plentiful there as north of Wallaceton.

In one lump of clay matrix, about the size of a walnut, obtained from the bottom of the dredgings north of Wallaceton, we discovered, on a preliminary microscopic examination, a very few diatoms, and a few, though perhaps a slightly larger number of sponge spicules. A separation and cleaning of the diatoms from this lump of clay was made by a fellow member of the Academy, John A. Shulze, after which the forms were identified by another member, Prof. C. S. Boyer. The mollusks were jointly identified by Prof. H. A. Pilsbry of the Conchological Section of the Academy and C. W. Johnston, Curator of the Wagner Free Institute of Science.

Below we tabulate the mollusks according to their range in geological time into three columns headed Miocene (M), Pliocene (P) and Recent (R)—under Recent are included both Pleistocene and now living forms. On the right, in two additional columns, we note the occurrence of such of the forms as have been found in the Croatan, N. C., and the Waccamaw, S. C., beds, both of which contain a somewhat similar molluscan fauna.

The geological range, as noted in the first three columns, we take from Dr. W. H. Dall's "Tables of Species" from the Waccamaw and the Croatan beds.[1]

[1] Transactions of the Wagner Free Institute of Science, Vol. III, Part 2, pages 210 to 215.

The Croatan beds are in North Carolina, about 120 miles slightly west of south of the Dismal Swamp, and about eighteen miles from the nearest point on the coast. They are on the northern border of a similar swamp area on the southern side of the Neuse River, and are about fifteen miles below Newbern. Both the Croatan and the Dismal Swamp shell localities are approximately 75 or 80 miles eastward of the rocks of the Piedmont plateau, which rocks bound the inland border of the less consolidated beds of the Atlantic Coastal plain. The two localities occupy a similar position both geographically and stratigraphically.

The Waccamaw beds are in the extreme eastern part of the State of South Carolina, and are exposed along the banks of the Waccamaw River from some four miles, to about 18 miles above Conway. They are on low ground, and are also on the western side of another of the swamp areas that occur on the seaward margin of the coastal plain from Cape May County, N. J., to South Carolina and Georgia. Geographically, they are similarly situated to the Croatan and the Dismal Swamp localities.

Fossil mollusks from the Croatan and the Waccamaw localities have been carefully studied and listed by Dr. W. H. Dall, who refers both beds to the Pliocene. The fauna, however, when considered with reference to the percentage of recent over extinct forms, would indicate that the Croatan beds were slightly the younger of the two deposits, there being, according to Dr. Dall, 83 per cent. of recent forms in the Croatan and only 70 per cent. in the Waccamaw beds. In summing up, Dr. Dall says "the Croatan beds are obviously newer than those of the Waccamaw, yet when compared with the admitted Pleistocene beds of South Carolina such as those of Simmons Bluff, the presence on the Neuse" [the locality of the Croatan beds] "of 41 out of 90 species, which have not been known later than the Pliocene, forbids us to regard the fauna as later than Pliocene."

In the study of the mollusks from the Dismal Swamp Canal the writer has had the advantage of some correspondence with Dr. W. H. Dall and of consultation with Prof. H. A. Pilsbry and C. W. Johnson, the latter of whom has collected a full series of shells from the Croatan beds, and a like series from the Waccamaw beds, both of which collections are now displayed in the Museum of the Wagner Free Institute of Science of Philadelphia, and with which the shells from the Dismal Swamp have been carefully compared.

The three species previousiy noted as having been collected from the bottom of the old south level near South Mills, N. C., were *Urosalpinx cinerea*, *Fulgur carica* and *Ostrea virginica*—the elevation of the surface at this point being about 11 feet.

All the forms, however, listed below, excepting *Urosalpinx cinerea* Say, were obtained from a locality along the Deep Creek level of the Old Canal, at a point four miles north of Wallaceton, Va., and from a depth of about ten feet, the elevation of the surface being about sixteen feet. The Deep Creek level is next north of the summit level of the old canal, the latter having an elevation of about twenty feet.

Ostrea virginica, generally much larger and more numerous than at South Mills or at north of Wallaceton, was likewise brought up in the dredgings from the bottom of the feeder leading from Drummond Lake, say at approximately ten feet below the surface level, which, at the point under consideration, is about twenty feet above tide, the elevation of the surface of the lake being, according to a survey made by the U. S. Engineers during the winter of 1895–1896, $22\frac{16}{100}$ feet.

Mollusks from the base of a low escarpment on the western border of the swamp near Suffolk, Va., and near the Jericho Canal, which leads north-westwardly from Lake Drummond to the Nansemond River, have been noted by Prof. N. S. Shaler. After listing the species as identified by Dr. W. H. Dall, he says: "Traces of this same deposit occur a few miles south of Suffolk, and I suspect the existence of similar beds near Elizabeth City. From certain comminuted fragments taken from the bottom of the main Dismal Swamp Canal, it seems to me not improbable that the beds were touched in making that excavation. I am, therefore, disposed to believe that the foundation rocks beneath the swamp district consist mainly of the beds indicated by the foregoing list of fossils."[2]

Prof. Shaler thus indicates fossil beds which the recent deepening of the Dismal Swamp Canal has abundantly verified, though very few of the species in Prof. Shaler's collection and our own are the same; and yet, as will be seen further on, upon analyzing the forms in the two collections, they tell a similar geological tale.

We now insert tables of the mollusks from the Dismal Swamp and the Jericho Canal localities.

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[2] Tenth Annual Report U. S. Geol. Survey, page 316.

TABLE OF SPECIES OF MOLLUSKS DREDGED FROM THE DISMAL SWAMP CANAL IN NORTH CAROLINA AND VIRGINIA.

Mollusks.	Range in time. M.	P.	R.	Found also in the Croatan beds, N. C.	And in the Waccamaw beds, S. C.
Arca limula Conr., one	x	x		o	o
Arca plicatura Conr., var. *sublineolata* D'Orb., numerous	x	x			
Corbula contracta Say	x	x	x	o	o
Cytherea convexa Say = (*C. sayana* Conr.)	x	x	x	o	o
Mulinia (*Mactra*) *lateralis* Say	x	x	x	o	o
Nucula proxima Say	x	x	x		
Venus mercenaria Lam'k	x	x	x	o	o
Lucina crenulata Conr	x	x	x	o	o
Olivella nitidula Dillw	x	x	x	o	o
Polynices (*Natica*) (*Neverita*) *duplicata* Say	x	x	x	o	o
Tornatina (*Bulla*) *canaliculata* Say	x	x	x	o	o
Nassa obsoleta Say, few	x	x	x	o	o
Divaricella (*Lucina*) *quadrisulcata* D'Orb	x	x	x		o
Cæcum cooperi Smith		x	x		o
Ostrea virginica Gmel		x	x		
Crepidula plana Say		x	x	o	o
Eupleura caudata Say		x	x	o	o
Fulgur canaliculatum Say, one		x	x	o	o
Fulgur carica Gmel., numerous		x	x	o	o
Nassa trivittata Say, numerous		x	x	o	
Scala lineata Say		x	x	o	
Turbonilla reticulata Ads		x	x	o	o
Spisula (*Mactra*) *solidissima* Dillw			x		
Tellina tenera Say			x		
Solen americanus Gmel			x	o	o
Urosalpinx cinerea Say			x	o	o
Coral.					
Astrangia danae Agas			x		

For comparison with the above we tabulate in a similar manner the list of fossils obtained by Prof. N. S. Shaler, from the northwestern part of the Dismal Swamp, near Suffolk, and identified by Dr. Dall. We take the list from Prof. Shaler's monograph on the Dismal Swamp in the Tenth Annual Report of the United States Geological Survey, page 315.

TABLE OF MOLLUSCAN SPECIES FOUND IN BEDS EXPOSED BY A ROAD CUTTING NEAR THE JERICHO CANAL, TWO MILES EAST OF SUFFOLK, VA.

	Range in time. M.	P.	R.	Found also in the Croatan beds, N. C.	And in the Waccamaw beds, S. C.
Arca incile Conr	x				
Crassatella undulata Say	x				
Mactra congesta Conr	x			o	
Anachis (*Columbella*) *avara* Say			x		o ?
Turritella apicalis Hp. (var.)		x			
Pecten eboreus Conr	x	x			o
Abra aequalis Say	x	x	x	o	o
Callista convexa Say (=*C. sayana* Conr.)	x	x	x	o	o
Eryphyla lunata Conr	x	x	x	o	
Gouldia cerina Ad	x	x	x		
Leda acuta Conr	x	x	x	o	o
Lucina crenulata Conr	x	x	x	o	o
Yoldia limatula Say	x	x	x	o	
Dosinia elegans Conr		x	x		o
Ostrea virginica Gmel		x	x		
Pecten exasperatus Sowb		x	x		
Crepidula convexa Say		x	x	o	o
Liomesus stimpsonii Dall		x	x		
Turbonilla interrupta Totten		x	x	o	o
Cadulus carolinensis Bush			x		
Cardium islandicum Lin			x		
Chione albida Gmel			x		
Nucula tenuis Mtg			x		
Tellina tenta Say			x		
Tellina modesta Verrill			x		
Scalaria clathratula Adams			x		
Ethalia ——— Sp. ? fragm					
Eulima ——— Sp. ?					
Balanus ——— Sp. ?					

Of the 26 species of mollusks from near Wallaceton, 17 occur at both Croatan and Waccamaw, 2 others occur at Croatan and not at Waccamaw, and still 2 others at Waccamaw and not at Croatan, while 5 have not been recorded at either of these two localities.

Of the 26 specifically identified out of the 29 forms from near Jericho, 6 occur at both Croatan and Waccamaw, 1 occurs at Croatan only, and 3 at Waccamaw only, while 16, more than half of which are recent, have not been noted at either of these localities.

In the lists above there are but 3 species occurring in both localities, viz.: *Cytherea convexa*, *Lucina crenulata*, and *Ostrea virginica*. Adding the numbers in the two lists and deducting these three, since they have been counted twice, we find there are, altogether, 52 molluscan forms, of which 3 are not specifically identified. Analyzing the remaining 49, we find their numbers range in geological time as follows:—

	M.	M. & P.	P.	M. P. & R.	P. & R	R.	Totals.
From near Wallaceton		2		11	9	4	=26
From near Suffolk.....	3	1	1	7	6	8	=26
	3	3	1	18	15	12	=52
Deduct common to both localities.....				2	1	3	
Total	3	3	1	16	14	12	=49

From which it will be seen that there are

Miocene and pre-Pliocene forms	7 species.
Ranging from Miocene to Recent	16 species.
Both Pliocene and Recent	14 species.
Recent, including Pleistocene	12 species.

Judging from these proportionate figures alone, which show 42 forms still living, out of a total of 49, the writer would be inclined to assign the age of the beds from which these fossils were obtained as not earlier than late Pliocene time, while it may even possibly belong to Pleistocene time.

We may, however, more particularly note other reasons for this conclusion as to age.

Twenty-six, or fully one-half of the shells specifically identified, clearly have a post-Miocene aspect, including two forms, *Fulgur carica* and *Ostrea virginica*, which are the most numerous of the collection. The specimens of *F. carica* present a peculiarity of sculpture which distinguishes them from the shells now living upon the coast; the surface being densely scored by fine crimped or undulating spiral striæ, in fully adult, large individuals. In recent shells of similar size such striation is nearly obsolete or wholly wanting, even when the superficial coat has not been removed by erosion.

Sixteen other forms have a persistent range from the Miocene through the Pliocene and Pleistocene periods down to the present time.

If we include these 16 as representatives of recent time, we have, as noted above, 42; or, as pointed out by Dr. Dall in a letter from which we quote, "nearly all the species as recent."

One other form, *Arca limula*, is usually considered distinctively Miocene, but its presence may be accounted for by considering it as an introduction from the underlying Miocene beds, which are probably not over 50 feet from the surface in this region. Bearing upon this, the writer may say that he has in his possession artesian well borings recently made at Old Point Comfort and Norfolk, Va. At Old Point Comfort, at the depth of 50 feet, were a number of shells, among them such Miocene forms as *Dosinia acetabulum* and *Pecten madisonius*, while at Norfolk there were obtained, at the depth of 105 feet, a fragment of *Pecten madisonius*, at 115 feet a perfect shell of *Gnathodon clathrodon*, and at 175 feet a fragment of *Pecten ebureus*.

Respecting another form in the Dismal Swamp bed, *Arca plicatura*, or perhaps a variety thereof, Dr. Dall says, after an examination by him of a number of specimens of this species which I had sent him: "The *Arca* you send is one which occurs in the [illegible] County Natural Well, North Carolina, and which was named by Conrad *Arca lineolata;* but as there was already a species of this name, D'Orbigny re-named it *sublineolata*. It appears to be a mutation of *A. plicatura*, to which I have referred it in my (MS.) work on the Tertiary Arcas of the United States. There was one Pliocene species in the fossils from the Jericho Canal,[3] and as the Duplin beds are at the very top of the Miocene, it would not be strange if *A. sublineolata* overlapped."

Bearing still further upon the entire subject, we further quote Dr. Dall from the same letter:—

"The species from your list[4] are all recent except *Arca limula* [and *Arca sublineolata*], but some of them are not now found so far north. Now we know that in Pliocene times some northward advance was made by the warm water species, such as *Gnathodon* and *Cyrena*. There are too many recent species (assuming that the fauna is not a mechanical mixture of shells of different ages) for the refer-

[3] This has reference to the bed near Suffolk, the forms from which appear in the second of the preceding lists.

[4] Reference is here made only to the first list, that from near Wallaceton.

ence of this fauna to the Upper Miocene—and we know that the extinct species [*A. limula* and *A. lineolata*] are not quaternary even in Florida—so, subject to the above assumption, I think we shall have to regard it as Pliocene. * * * * The Croatan beds are distinctively Pliocene, but these are more like the contact between the southern Pliocene and a more northern cold water fauna."

Corroborative of the views already advanced as to the age of this bed is the following, written by Prof. N. S. Shaler respecting the mollusks listed above from near the Jericho Canal: "The species determined by W. H. Dall, paleontologist of the U. S. Geological Survey, indicates in a general manner that the beds are of Pliocene age. Of the 29 species that appear in my collection, 24, according to Dr. Dall, belong to living forms and 5 are extinct. The extinct species are found in the so-called Pliocene of Florida, South Carolina and Virginia. There can be no question the deposit is of preglacial age."[5]

We now consider the evidence presented by the diatom flora which we think corroborates that presented by the mollusks for reasons which we shall note after the introduction of the following statement by Charles S. Boyer, A. M., made by him after a careful examination of a number of mounts prepared from the material which had been reliably cleaned, as already stated, by John A. Shulze, and to which we are well assured there has been no admixture of diatoms from any other source:—

"The following list includes all the forms, 31 in number, found in the slides of the Dismal Swamp material except a few fragments which were too small for accurate determination.

"In the middle column is noted the relative frequency and rarity of some of the forms in comparison with the rest as seen in the strewn mounts:—

"Of the above forms all but four are strictly marine. The exceptions are *Navicula major* and *Stauroneis Phoenicenteron*, which are fresh water, *Campylodiscus Echeneis* which is both brackish and fresh water, and *Melosira crenulata* var. *antiqua*, which is possibly also fresh water.

"I think I have named all on the slides at hand, except probably one or two forms of *Coscinodiscus* and *Navicula*, which were in fragments.

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[5] Tenth Annual Report, U. S. Geol. Survey, page 315.

"Of the 31 named, 2, *Actinoptychus Heliopelta* and *Aulacodiscus Rogersii* are distinctly Miocene; 4, *Coscinodiscus robustus*, *Stephanopyxis aculeata* and *Corona*, and *Triceratium semicirculare* are quite

Actinocyclus Ehrenbergii Ralfs	Common	Miocene and Recent
Actinoptychus Heliopelta Grun	Rare	Miocene only
Actinoptychus undulatus E	Common	Miocene and Recent
Aulacodiscus Rogersii (Bail) A. S	Not uncommon	Miocene only
Auliscus caelatus Bail		Miocene and Recent
Auliscus punctatus Grun		Miocene and Recent
Biddulphia Rhombus (E.) Wm. Sm		Miocene and Recent
Biddulphia Tuomeyi (Bail) Roper		Miocene and Recent
Campylodiscus Echeneïs E	Not uncommon	Fossil in Deposits later than Miocene also Recent. Brackish and Fresh Water.
Cerataulus turgidus E		Later than Miocene, also Recent
Coscinodiscus apiculatus E		Miocene and Recent
Coscinodiscus Asteromphalus E		Miocene and Recent
Coscinodiscus bulliens A. S		Miocene and Recent
Coscinodiscus marginatus E		Miocene and Recent
Coscinodiscus radiatus E		Miocene and Recent
Coscinodiscus robustus Grev		Miocene
Craspedodiscus Coscinodiscus E		Miocene and Recent
Eupodiscus radiatus Bail. Although var. *antiqua* Cox is found in the Miocene.		Recent Later than Miocene
Gomothecium Rogersii E		Miocene and Recent
Hyalodiscus laevis E		Miocene and Recent
Melosira sulcata E		Miocene and Recent
Melosira crenulata var. *ambigua* Grun. Fossil in Hungarian deposit (Miocene?), as, however, there are numerous varieties which are recent, this may be so also		Fresh Water?
Navicula Gruendleri A. S		Recent, marine
Navicula major Kutz	Common	Miocene to Pleistocene, also Recent Fresh Water.
Plagiogramma Gregorianum Grev		Miocene and Recent
Pseudauliscus radiatus A. S		Miocene and Recent
Stauroneis Phœnicenteron (Nitzsch) E		Later than Miocene, also Recent Fresh Water.
Stephanopyxis aculeata E		Miocene
Stephanopyxis Corona (E.) Grun		Miocene
Triceratium robustum Grev		Miocene and Recent
Triceratium semicirculare Br		Miocene

characteristic of that period, while of the remaining 25, only 4, *Campylodiscus Echeneis*, *Cerataulus turgidus*, *Eupodiscus radiatus*

and *Stauroneis Phoenicenteron* can be considered as distinctive of later deposits.

"In general, therefore, it may be said that the deposit can be considered as a mixture of Miocene and later deposits, though the latter need not necessarily have been so *very* recent."

From an examination of the above list of diatoms the present author would classify them as follows: Six forms characteristically Miocene, 19 forms that have survived from Miocene to present time and are now living, and 4 either Pliocene or Pleistocene, or both, and also now living. These 4 are the same as those noted above by C. S. Boyer as distinctive of deposits later than Miocene.

If the 19 survivals belong to present time, there are 23 that may be considered recent, or comparatively so. Respecting the exclusively Miocene forms it is probable that these have been brought down in post-Miocene times by the James River in its passage over the original beds from Richmond southeastward. It is probable also that some of the individuals of perhaps each of the 19 species having the more cosmopolitan range were also similarly introduced. We are confirmed in this view by the occurrence among the characteristic Miocene diatoms of *Actinoptychus Heliopelta*, a form which the writer has frequently found heretofore both in outcrops and in well borings, but always at or below the base of the great 300 to 400 feet Miocene diatomaceous clay bed of the Atlantic Coastal Plain. In Maryland it occurs at the base of this bed in well borings at Crisfield and in outcrops at and near Nottingham on the Patuxent River. In Virginia it has been found in outcrops at Petersburg and Bermuda Hundred. In New Jersey, owing probably to a thickening of the basal beds of the Miocene, it occurs some distance below the main diatom bed. It has thus been found in outcrops near Shiloh and in well borings at Asbury Park and Wildwood. At the latter place it was found in a thin seam of clay about 250 feet below the bottom of the great diatom bed. In each instance just cited its position is at or very near the base of the Miocene, either resting directly upon or only a short distance above greensands of Eocene Age. Many other borings have been made in New Jersey through or nearly through these beds, from which the writer has had complete series of specimens every 10 to 20 feet apart, all of which he has examined, but in none of them has he ever found *A. Heliopelta* stratigraphically higher than near the base of the Miocene. Now the diatom bed outcropping at Richmond, Petersburg

and vicinity has been found by the writer in the Norfolk well boring at between the depths of 585 and 625 feet, while the continuation upward of the same clay contained sponge spicules up to about 400 feet from the surface. No diatoms or sponge spicules were found higher in this well excepting between the depths of 25 feet and 65 feet, where a stratum, probably the equivalent of the Dismal Swamp bed, contained these same micro-organisms, though, as in the Dismal Swamp deposit, very sparingly. The Miocene beds at Bermuda Hundred and Petersburg are rich in diatoms, and especially so in *A. Heliopelta*, and since the diatoms in the Dismal Swamp deposit were exceedingly meager, (perhaps not one per cent. of the entire matrix), and since *A. Heliopelta* and other Miocene species were scantiest in numbers of all the contained forms, we cannot, in view of all the facts, consider that the introduction of these Miocene forms has been by other than mechanical means in post-Miocene times. At what period that subsequent time was, three of the more recent forms, *Campylodiscus Echeneis*, *Cerataulus turgidus* and *Stauroneis Phoenicenteron*, shed much light. We will now particularly notice each of these forms.

In a mass of brick clay from a low terrace at Bridgeton, N. J., which terrace is assigned by the New Jersey State Geological Survey report to a very recent geological phase of the gravels of that State, the writer found a very considerable number of diatoms not at all Miocene in aspect, and among them a large number of the same species of *Cerataulus*.

Respecting *Campylodiscus Echeneis* it may be stated that this form has been recorded as living principally in brackish waters the world over, though Prof. C. S. Boyer informs the writer that he has found it in a fresh water reservoir at Philadelphia, supplied from the Schuylkill River. Though not, however, heretofore recorded, so far as we are able to learn, as fossil, yet the writer has so seen it in a low level clay from near Buckshutem on the Maurice River, below Millville, N. J., the stratigraphical position of which is the equivalent of the Bridgeton clay above referred to.

On a map of the surface formations of New Jersey in the annual report of the geological survey of that State for 1897 there is shown a low level formation on the shores of Raritan Bay and thence bordering the Atlantic Ocean from Sandy Hook to the Cape May peninsula, which it either entirely covers or nearly so, and thence extending up the Delaware River nearly to Trenton. This low lying terrace,

which is stated in the text to have an elevation of 30 to 50 feet, extends inland along the courses of the following streams: some 20 miles up the Mullica and the Great Egg Harbor Rivers, about 25 miles up the Maurice River, and some 10 miles up the Cohansey River. These measurements were made in a direct line from the mouths of the rivers and not by following the winding courses thereof. The surface deposit of this terrace has been named by Prof. R. D. Salisbury the Cape May Formation. He describes it as a "thin body of loam, sand and gravel of lesser age than any" of the surface formations of the State described in the same paper "except possibly the drift of the last glacial epoch." He further says: "The strict contemporaneity of this formation with the drift of the last glacial epoch is not established, but it is probably at least partly contemporaneous with it, though its later portions may be still younger."[6] To this formation belong the diatom clays noted in the preceding paragraphs as at Bridgeton and Buckshutem.

Stauroneis Phoenicenteron has never been seen by the writer in any of the numerous specimens of Miocene diatomaceous clays which he has examined during the past ten years, nor has it, so far as he has been able to learn from consultation of the literature relating to it, been recorded by others as occurring in beds of that age. It has, however, a world wide distribution in freshwater deposits of decidedly later age. Ehrenberg, in the Atlas of his Mikrogeologie, notes it in various sands and black, white and gray earths at numerous localities (named below) most of which the writer would characterize from their position stratigraphically and geographically as decidedly post-miocene and some of them as clearly glacial and post-glacial. Thus Ehrenberg lists this diatom on page 19 of his Atlas as occurring in various earths and at different places, as follows:—in lake mud from Loka, Sweden; in Bergmehl from Degenfors and Lillhaggsjohn, Sweden, also from Santa Fiora, Italy, and from the south point of Tierra del Fuego, S. A.; in Blätterkohl from Westerwalde, Prussia; in white earth from Guatemala; in Kieselguhr from Andover, Pelham and Wrentham, Massachusetts; from Ceyssatt, France; from Down, Mourne Mountains, Ireland; from New Hampshire and from Earlton, Nova Scotia; in white marl (Mergee); from Farmington, Conn.; in Meteorpapier, from Rauden, Prussia; in tripoli and polishing powder, from Moscow, Russia; and in Weisenpapier, from Freiberg, Saxony.

[6] Annual Report Geol. Survey of N. J., 1897, page 19.

It has also been found fossil by Prof. C. S. Boyer, in specimens of clays obtained by the writer from the upper portions of two well borings, one on the beach at Wildwood,[7] Cape May Co., N. J., and the other at Rock Hall,[8] Md., on the eastern side of Chesapeake Bay opposite the mouth of the Patapsco river. The clays referred to occupied, at Wildwood, the interval between the depths of 79 and 181 feet, and at Rock Hall a similar interval between the depths of 50 and 130 feet. The clays at both localities contained a mixture of fresh-water and marine diatoms, the numbers of individuals of the fresh-water forms somewhat exceeding those of the marine. That these two deposits are probably synchronous in age appears probable from the similarity of their position next below the surface formation (Cape May formation?), also from the similarity of the assembled forms of diatoms, and from the occurrence in both of a unique diatom, *Polymyxus coronalis*, L. W. Bailey, not however, found in our examination of the forms in the Dismal Swamp bed. This form has not been heretofore known except as living off the mouths of the Para and Amazon Rivers in South America. That the two deposits are much later than Miocene in age may be inferred from the fact that the one at Rock Hall lies directly upon the Rancocas division of the Cretaceous, the Miocene itself resting at a higher level upon Eocene beds a few miles southward and eastward; while at Wildwood the top of the great Miocene diatom clay bed occurs nearly 200 feet deeper than the base of the deposit under consideration, or at the depth of 370 feet from the surface. The well borings, however, show that apparently the same Miocene clay, but without diatoms, commences at the depth of 294 feet.

These two deposits containing *Polymyxus coronalis* and *Stauroneis Phoenicenteron*, the writer suggests were probably laid down in the deltas of the ancient Delaware and Chesapeake Rivers at the time when the shore line of the Atlantic Coastal plain was many miles eastward of its present position and much of the now submerged portion of the plain was above sea level.

SUMMARY.

After considering the position of the Dismal Swamp bed, beneath a low lying terrace on the eastern margin of the Coastal Plain and evidently resting immediately upon fossiliferous Miocene beds which

[7] An. Report Geol. Survey of N. J. for 1894, page 165.
[8] In manuscript, not yet published.

can be traced westward along the James River some eighty miles or more to Richmond, Va., and after a careful study and analysis of the contained mollusks and diatoms the conclusion before stated has been reached that both the macroscopic and the microscopic fossils indicate a mechanical mixture of the Miocene and a comparatively recent fauna and flora[9] the Miocene forms having been contributed and brought down by erosion from the broad and somewhat higher and gradually rising Miocene belt to the westward, while the more recent forms lived and were deposited as the bed was laid down in a more recent geological time.

If we accept the conclusions of all the authorities we have quoted who have studied the Dismal Swamp deposit, we should have to refer this bed unequivocally to the Pliocene period. The writer, however, cannot resist inferring from the scantiness of Miocene fossils, which, as already noted, he views as mechanically introduced—from the wide range of many of the Pliocene mollusks, extending down to the present time—from the very decidedly recent aspect of many other shells—and from the even more decidedly recent aspect of some of the diatoms, a more recent date for the bed, and therefore considers that it cannot belong to a period earlier than the latest Pliocene, and that it may, indeed, even belong quite within Pleistocene time.

Specimens of all the mollusks listed from the Dismal Swamp Canal have been presented to the Academy of Natural Sciences by M. Homer, and are now arranged in its paleontological collection, while strewn mounts of the diatoms have been deposited in the cabinet of the Biological and Microscopical Section by the author.

[9] Diatoms are now generally regarded as belonging to the plant kingdom.